REINFORCED FIBER PANEL AND METHOD OF FORMING SAME

BACKGROUND OF THE INVENTION

The present invention relates to three-dimensional structural products, and more particularly to structural products made from wood products and methods of forming same.

Structural panels can be used in a variety of applications, including applications similar to those in which plywood or lumber conventionally are used. For instance, structural panels can be used in the construction of pallets. Pallets and similar support devices are common articles that are used to transport goods in a variety of industries. Pallets can come in many shapes and sizes, and are typically formed from wood planks or molded plastic. While these types of pallets are commonplace, they suffer from several disadvantages. First, pallets formed from wood planks require first quality pieces that are free from serious defects that could compromise the integrity of the pallet. Not only does obtaining quality wood add to the cost of the pallet, a significant portion of the supply trees are wasted during production. In addition, the wood planks forming the pallet are typically nailed together. The nailed joints may be sturdy at first, but they tend to fail due to the rigors of transporting goods. In fact, normal use typically destroys most pallets after an alarmingly low number of uses, as weather, product weight, and mishandling all play a role in their demise. Instead of repairing broken pallets, however, most users simply throw the pallets away, which creates further waste and increases the costs of transporting goods.

Molded plastic panels are also disadvantageous, in that they are constructed of non-natural materials that do not break down after the panels have been discarded. Plastic panels also tend to have low bending resistance, which limits the applications suitable for plastic panels.

Structural panels have been developed that address some of the shortcomings of wood plank and plastic panels. For example, U.S. Patent No. 4,702,870 to Setterholm et al., the disclosure of which is incorporated herein by reference, discloses molded panels made of wood fiber from hardwood trees that are relatively small, deformed or otherwise not well shaped to produce commercial sizes and quantities of lumber, and limbs of

larger hardwood trees that are not utilizable for lumber. Setterholm's panels utilize wood fibers that are processed into a slurry and then deposited on top of a mold. A normal force is applied to the slurry in conjunction with heat and vacuum to form the panel structure. One advantage of the Setterholm panels is that many different types of wood fibers, including soft wood fibers and hardwood fibers, can be used in the invention to more efficiently utilize the wood resources currently available.

Unfortunately, the inventors of the present invention have discovered that panels created by the teachings of Setterholm and/or similar techniques are susceptible to significant deformation when placed under load. This deformation can lead to immediate failure of the panel or greatly reduce the fatigue lifespan of the panel. Because of the nature of the materials forming the panel, there is a need to improve the bending resistance of such panels. There is also a need for forming a panel that has improved structural properties, yet that remains low in cost and can be produced efficiently.

BRIEF SUMMARY OF THE INVENTION

These and other needs are provided by the present invention that describes a reinforced product, such as a pallet, made from panels comprising fibrous materials, such as paperboard. Advantageously, the panel is structurally reinforced for greater strength by providing a channel and reinforcing member along at least a portion thereof. The reinforcing member is fitted into the channel and bonded therein to enhance the bending stiffness of the panel. The reinforcing member preferably comprises a paperboard lamination formed from multiple plies of paperboard or papermaking fibers adhered together and then folded to form the desired cross-sectional shape. The plies of the reinforcing member preferably are dry-bonded to each other using an adhesive, such as a modified silicate adhesive. Such a dry-bonding process adds little or no moisture to the structure. In one aspect of the invention, the panel is reinforced by being bonded to another panel, which may or may not have a reinforcing member of its own.

In particular, one embodiment of the invention includes a reinforced panel for supporting objects that includes a face sheet having an interior side and an exterior side, and a plurality of integral and intersecting ribs having distal ends and projecting from the interior side of the face sheet to form contiguous cells. The ribs define at least one

channel extending across a plurality of the contiguous cells, and the channel may have one of many shapes. The contiguous cells may also have various cross-sectional shapes, such as round, elliptical, oval, and polygonal. A planar sheet may or may not be attached to the distal ends of the intersecting ribs.

A reinforcing member is positioned in the channel and bonded thereto for increasing the bending resistance of the panel. The reinforcing member can be of various shapes and sizes, including polygonal, circular, oval, and elliptical. In addition, the reinforcing member can have a cross-sectional shape, such as T-shaped, I-shaped, V-shaped, |-shaped and L-shaped. In one embodiment, the reinforcing member has a top end that is flush with the distal ends of the ribs, but in another embodiment the reinforcing member extends beyond the distal ends of the ribs.

In another embodiment of the present invention, a reinforced panel is provided that includes a first face sheet and a second face sheet, each having an interior side and an exterior side and a plurality of integral and intersecting ribs having distal ends and forming contiguous cells. At least one of the ribs of the first and second face sheets defines at least one channel extending across a plurality of the contiguous cells. A reinforcing member is positioned in the channel and secured thereto. In one embodiment, each face sheet defines a channel therein, although it is possible that only one face sheet defines a channel. If more than one channel is defined by the panel, one or more reinforcing members may be present that can extend from one face sheet to another, or it is possible that each face sheet has a reinforcing member such that the reinforcing members are adjacent one another. The reinforcing member can be made from paperboard, wood, metal, plastic, and combinations thereof.

In yet another embodiment, the face sheet is arranged such that the exterior side of the face sheet defines a channel, such as by folding one end of the panel on itself to form the channel. A reinforcing member is positioned in the channel in order to increase the bending resistance of the panel. In one such arrangement, the panel includes two face sheets, each having a plurality of integral and intersecting ribs, and wherein the face sheets are arranged so that the ribs of each face sheet are proximate the ribs of the other sheet. In all of the above embodiments, the panel is of superior strength and durability, which improves the lifespan and reduces costs of operation.

Methods are also provided by the present invention. In particular, one method of the present invention includes forming a reinforced panel for supporting objects including the steps of forming a first face sheet having a plurality of integral ribs extending therefrom, whereby the ribs have distal ends and form contiguous cells. A first channel is formed in the first face sheet that extends across a plurality of the contiguous cells, and a first reinforcing member is secured in the first channel for increasing the bending resistance of the panel. In one embodiment, the channel forming step and the face sheet forming step occur concurrently, such as by pressing and heating a slurry of paperboard material in a mold so that the channel is formed during the creation of the face sheet. Alternatively, the channel may be cut into the first face sheet after the face sheet has been formed. The first reinforcing member may be secured in the channel such that the reinforcing member is flush with the distal ends of the integral ribs, although it is possible that the reinforcing member may be secured in the channel so that a portion of the reinforcing member extends beyond the distal ends of the integral ribs. In another embodiment, the method further includes forming a second face sheet having a plurality of integral ribs, and forming a second channel that extends across a plurality of the cells defined by the ribs. A second reinforcing member may also be provided, and the second reinforcing member, the first reinforcing member, or both, are attached to the second channel. The first face sheet and the second face sheet are also attached to one another in order to provide a panel having increased bending resistance.

Accordingly, the panel and methods of forming a panel according to the present invention provide a structure having superior bending resistance over conventional paperboard or wood based structures. In addition, the panel of the present invention overcomes the disadvantages of wood plank and plastic panels and the like. Advantageously, the structures and methods afforded by the present invention are low cost, highly efficient, and safe.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a perspective view of a reinforced panel according to one embodiment of the present invention;

Figures 2A-2C illustrate various cross-sectional views of integral and contiguous cells according to the present invention;

Figures 3A-3I show various cross-sectional views of a reinforcing member according to the present invention;

Figure 4 illustrates an alternative embodiment of a reinforced panel according to the present invention;

Figure 5 illustrates yet another alternative embodiment of a reinforced panel according to the present invention;

Figures 6-10 illustrate selected steps for forming a reinforced panel according to one embodiment of the present invention;

Figures 11-15 illustrate selected steps of an alternative method of forming a reinforced panel according to the present invention;

Figure 16 illustrates a perspective view of an alternative reinforced panel according to the present invention; and

Figure 17 illustrates an alternate arrangement of the panel shown in Figure 16.

DETAILED DESCRIPTION OF THE INVENTION

The present inventions now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

Turning now to the figures, Figures 1 and 2 show a reinforced support structure or panel **20** according to one embodiment of the present invention. The panel **20** is useful for supporting objects and transporting goods, although other uses and benefits are contemplated by the present invention. As shown, the panel **20** has opposing ends **21** and sidewalls **23**. The thickness of the panel **20** is defined as **H1**, and is determined by the distance between a top or interior side **22** and a bottom or exterior side **24** of a face sheet

26. The face sheet **26** is preferably formed of fibrous materials, such as wood fibers described in U.S. Patent No. 4,702,870 to Setterholm, et al., which is discussed above. Recycled fibrous materials may also be used, as well as plastics and composites. The interior side **22** and exterior side **24** of the face sheet **26** are generally planar and smooth, although it is possible to have a roughened surface on either or both of the sides. In one embodiment, a planar sheet **38** forms part of the panel **20** and defines an outer surface of the interior side **22**. The panel **20** can also be impregnated with resin to render it water-resistant, if desired.

The panel **20** also includes a plurality of integral and intersecting ribs **28** that extend from the bottom end of the face sheet **26** and have a distal end **30** at the top side **22** of the panel. The ribs **28** have walls **34** that define contiguous cells **32** of open space. As shown in Figures 2A-2C, the cells **32** may have a variety of shapes and sizes. In particular, the cells **32** may have a polygonal shape such as hexagonal (Figure 2A) or square (Figure 2B), or round (Figure 2C). The cells **32** provide stiffness to the panel **20** using a minimal amount of material. The exact shape and size of the cells **32** may be determined depending on the application and design choice, and other shapes and sizes are contemplated by the present invention.

The ribs **28** further define a channel **40** having a surface **42** that extends along the face sheet **26**. Although the channel **40** is shown as extending along a path parallel to the sidewalls **23** of the panel **20**, the channel **40** may extend along the line parallel to the ends **21**, or at an angle to the sidewalls or ends, or a combination thereof. As shown in Figure 1, the channel **40** is defined by the ribs **28** and extends between the top side **22** and bottom side **24** of the face sheet **26**. In order to provide increased bending resistance of the panel **20**, a reinforcing member **50** having a surface **52** is positioned within the channel **40** and secured thereto. Preferably, the channel **40** is sized to receive the reinforcing member **50** such that the surface **42** of the channel registers and forms a close-fitting relationship with the surface **52** of the reinforcing member. In one embodiment, the reinforcing member **50** is flush with the distal end **30** of the ribs **28**, although in an alternative embodiment the reinforcing member may extend beyond the distal end of the ribs.

Figures 3A-3I illustrate various embodiments and designs of the reinforcing member **50**. In particular, the cross-sectional shapes of the reinforcing member **50** include polygonal, such as a triangular shape (Figure 3A), circular (Figure 3B), oval (Figure 3C), elliptical (Figure 3D), T-shaped (Figure 3E), I-shaped (Figure 3F), V-shaped (Figure 3G), | -shaped (Figure 3H), and L-shaped (Figure 3I). The reinforcing member **50** preferably comprises a paperboard lamination formed from multiple plies of paperboard adhered together and then folded or arranged to form the desired cross-sectional shape. The plies of the reinforcing member **50** preferably are dry-bonded to each other using a modified silicate adhesive or the like. Such an adhesive and dry-bonding process adds little moisture to the panel **20**. Other materials may also be used to form the reinforcing member **50**, such as wood, plastic, metal, and combinations thereof. In one embodiment, the reinforcing member **50** is dry-bond laminated to the channel **40** so that the surfaces **42**, **52** have a strong bond therebetween. Other ways of securing the reinforcing member **50** include using other types of adhesives, pressing the reinforcing member **50** into a snap-fit or frictional fit, or other type of arrangement.

Figure 4 shows a perspective view of an alternative embodiment of the present invention, wherein a second face sheet **62** having a top end **63** and a bottom end **64** is placed on the face sheet **26** to form an overall thicker panel **20**. The second face sheet **62** also includes a plurality of cells **72** formed by a plurality of integral and intersecting ribs **76** having walls **78** and distal ends **70** that define the size and shape of the cells **72**. The face sheet **62** also has opposing ends **61** and sidewalls **65**, and the thickness **H2** of the face sheet is determined by the length of the ribs **76**. The face sheet **62** may not define a channel, but may instead only provide additional structural support. However, Figure 4 shows one embodiment where the face sheet **62** defines a channel **80** having a surface **84** that may have a size and shape as described above for the channel **40**. A reinforcing member **90** having outer surface **92** is shown in the channel **90** and positioned adjacent the reinforcing member **50**. More particularly, the reinforcing members **50**, **90** are arranged such that they are aligned when the face sheets **26**, **62** are placed together and bonded together to form a thicker panel **20**.

Figure 5 illustrates an alternative embodiment wherein the face sheet **26** defines a channel **40** that extends from the bottom end **24** to the top end **22**, and the face sheet **62**

defines a channel **80** that extends at least partially from the distal end **70** of the ribs **76** toward the top end **63**. However, the channels **40, 80** are sized and arranged to accommodate only a single reinforcing member **50** that is shared between the two face sheets of the panel **20**. More specifically, the reinforcing member **50** is positioned in the channels **40, 80** such that an upper edge **51** extends beyond the distal edge **30** of the ribs **28** and into the channel **80** defined by the face sheet **62**. The reinforcing member **50** is secured to both face sheets **26, 62** and provides increased bending resistance of the panel **20**, and also can assist with the registration and alignment of the face sheets.

Figures 16 and 17 illustrate alternative arrangements for the panel **20**. As shown in Figure 16, the panel **20** includes two face sheets **26, 62** that are bonded to one another as described above, yet neither face sheet defines a channel or includes a reinforcing member embedded therein. Instead, the face sheets **26, 62** are folded, molded, or otherwise manipulated so that a top surface **73** forms surfaces **73A-73D** that define a channel **40**. A reinforcing member **50** is positioned within the channel **40** and bonded thereto for providing increased bending resistance of the panel **20**. Likewise, the folded portion of the panel **20** is bonded to the remainder of the panel to form a strong, load-bearing structure. Figure 17 shows an alternative arrangement wherein the face sheets **26, 62** define a channel **40A** that is in communication with a channel **40B** formed by the wall **73** as shown in Figure 16. In this embodiment, the reinforcing member **50** has a "T" shape, although the channels **40A, 40B** and reinforcing member **50** can have various and complimentary shapes, such as those shapes described herein. The arrangements shown in Figures 16 and 17 and the process of forming these and other arrangements may be particularly advantageous when relating to runners of pallets and the like. The runners act as vertical risers or spacers on the bottom of the pallet and space the main supportive surface of the pallet from the ground. Advantageously, the reinforcing member **50** provides added stiffness to the runner to withstand bending and normal loads.

Methods of forming a panel according to the present invention are also provided and shown in Figures 6-15. In one method shown in Figures 6-10, a face sheet **26** is formed having a plurality of integral ribs **28** extending therefrom. As discussed above, the ribs **28** have distal ends **30** and form contiguous cells **32** having surfaces **34** in one or more of the shapes shown in Figure 2. In order to form a channel in the panel **20**, a

cutting device **86**, such as dual rotating cutting blades, a router, or the like, is brought into contact with the ribs **28** and top sheet **38**, if present (Figure 7). The cutting device **86** is lowered into the face sheet **26** so that a channel **40** is formed corresponding to the shape defined by the cutting device **86** (Figure 8). A corresponding reinforcing member **50** is then placed inside the channel **40** and secured thereto (Figure 9).

An alternative method for forming a panel **20** is shown in Figures 11-15 and includes utilizing a mold **83** having a plurality of mold inserts **85** distributed throughout, including a channel mold insert **98**. Figure 12 illustrates the deposition of previously prepared material, such as wood fibers **25**, on to the mold inserts **85**, **98**. At this stage, the prepared wood fibers **25** are uniformly distributed over the mold surfaces, yet have very little structural integrity. Figure 13 illustrates a forming step whereby a pressing device **89** is forced upon the wood fibers **25**, which compress under the load exerted by the pressing member **89** and by the mold **83** and mold inserts **85**, **98**. Water is expressed from the slurry through drainage holes (not shown) in the mold **83**, so that the panel **20** is densified. Figure 14 illustrates the forces presented during the pressing step. Heat and possibly suction are provided during this step in order to form the face sheet **26**. Finally, Figure 15 illustrates the completed face sheet **26** defining a channel **40** with surface **42** that is formed by molding the channel during the formation of the face sheet. As discussed above, a corresponding reinforcing member **50** is then secured in the channel **40** as describe above to provide structural support and increased bending resistance of the panel **20**.

Accordingly, the panel **20** of the present invention provides an improved and cost efficient structure that lasts longer, is environmentally conscious, and provides superior structural qualities compared to structures known in the art. The reinforcing member **50** can be one of many shapes, and in conjunction with the channel **40**, the reinforcing member can be quickly and easily positioned in the panel, even retroactively, to provide immediate structural support and increased bending resistance of the panel. While certain shapes and arrangements have been shown in the figures and described therein, the present invention contemplates panels having reinforcing members of different shapes and sizes present in the panel. The reinforcing members may also have various positions and arrangements depending on the particular use and properties desired of the panel. In

addition, the panels described herein may be used in a variety of applications, and are not limited to panels or pallets for transporting or supporting goods. Therefore, the present invention contemplates the panels described herein as being used in a broad range of structural and supportive applications.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.